Citation:

Calabrese EJ, Tuthill RW. The Massachusetts blood pressure study, part 3. Experimental reduction of sodium in drinking water: Effects on blood pressure. *Toxicology and Industrial Health.* 1985; 1: 19-34.

PubMed ID: 3842544

Study Design:

Randomized controlled trial

Class:

A - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To test whether a reduction in drinking water sodium (Na) concentration in a fourth grade population results in a corresponding decrease in blood pressure (BP) over a three-month period.

Inclusion Criteria:

Fourth graders from a high-Na concentration community who had participated in the previous year's study among third graders.

Exclusion Criteria:

Lack of informed consent.

Description of Study Protocol:

Recruitment

- Participation was solicited from the families of the fourth grade children in the high drinking water Na concentration community (HiNaC) whose parents had consented to their participation in the previous year's study among third graders
- The contact initially was by letter, with a follow-up telephone call, inviting parents to attend a series of informational meetings
- Subsequently, a mailing detailing what participation in the project would involve went out to all parents in conjunction with a statement of informed consent to be signed by parents.

Design

- Between March and June 1979, participating families would regularly receive bottled water to be used for all of the children's drinking water and for all water used in the preparation of foods and beverages to be consumed by the children
- Additionally, water of each type was provided in the classroom to serve the drinking needs of the children while at schools
- Three different types of water, distinguished for participants by cap color, were distributed and the children divided into three groups according to the type of water used
- Children were matched in triads of three students each on the basis of sex, school and baseline BP
- The members of each triad were randomly allocated to one of three bottled water conditions.

Blinding Used

- Participating children, their families, all school personnel and the nurses recording BP were blind to the group assignment of the children
- All personnel involved in the bottling and delivery process were blind as to the type of water denoted by the color-coded caps and labels.

Intervention

- Water distribution: Water was taken from the distribution system of each of the two towns, transported to the bottling facility and bottled in one gallon polypropylene containers at an FDA approved commercial bottled water facility. The three types of water were distinguished by color-coded caps and labels. The water was bottled and delivered to the individual homes and schools every two weeks during the study. Computerized delivery recorded were maintained on the amount and type of water delivered to households and schools for the duration of the study
- High group: Received water bottled directly from their own HiNaC water distribution system at approximately 110mg per L Na
- Low group: Received water bottled directly from the low drinking water Na concentration community (LoNaC) water distribution system at approximately 10mg per L Na
- Low+ group: Received water from the LoNaC water distribution system, with Na added up to the 110mg per L of the HiNaC.

Statistical Analysis

Paired and unpaired T-tests and analysis of repeated measures (adjusted for baseline weight and pulse) was used to compare groups.

Data Collection Summary:

Timing of Measurements

- Blood pressure measured on a biweekly basis with the first screening in the week before beginning the 12 weeks of bottled water usage
- Six subsequent screening followed, for the 12-week duration of the project
- Urine specimens and two-day diet records were collected monthly
- Height and weight were collected at baseline and the final screening.

Dependent Variables

- Blood pressure:
    - Screenings conducted at each of the seven schools in the community and were

scheduled for four mornings and three afternoons during each screening week. All participating children in any one school were screened in a single session. Some children were absent during screenings; for midpoint and endpoint weeks, extra effort was made to screen absent children at home or later in the week at school
    - Screening procedures were closely standardized among the seven schools. Children were brought to a suitable quiet location in each school for the screenings. No gym classes or active recesses were scheduled in the hour prior to screening and meals were not consumed for 45 minutes prior to screening
    - The three BP readings per student at each screening were averaged together for one representative BP value for each screening. The second and fourth week readings, the sixth and eighth week readings and the tenth and twelfth week readings were averaged to form their average monthly readings
- Height and weight: School scales were used, all of which weighed correctly [within one pound (lb)] of a 40-lb weight, a weight lower than the average weight of the children. The same scaled were used for the initial and final measurements
- Questionnaire: Components of the questionnaire regarding whether there were any changes in dietary habits, particularly salt use, over the study period.

Independent Variables

- First-morning urine specimens: Sterile sample containers and instructions for a clean-catch urine specimen were distributed each month on a Tuesday to the children at school to be taken home for Wednesday morning's use. Families were telephoned that night and arrangements made to deliver a specimen bottle to the home if it had been left at school, the specimens were returned to the schools in the morning and were immediately collected, placed on ice, and taken to the University. The specimens were analyzed for Na and K levels using an IL flame photometer
- Diet records: Distributed at monthly intervals. The children, with the aid of their teachers and parents, kept an ongoing record of all foods and liquids consumed for the 48-hour period from Monday lunch through Wednesday breakfast. Teachers and parents were instructed on how the records should be kept. Additionally, it was emphasized to parents that the meals served to their children should not differ in any way from usual practice
- Questionnaire: Information was solicited via questionnaire to assess how frequently the child ate the school lunch, at which time they were exposed to the regular town water, and the socioeconomic status of the family. In addition, the questionnaire information gathered during the previous year provided data on the length of residence of the children in the town; family history of high BP; and the infant feeding habits, commercially or home prepared solid foods and the age at which solid food intake was instituted.

Description of Actual Data Sample:

- *Initial N:* The families of 171 of the 353 children eligible to participate agreed to take part in the study
- *Attrition (final N):* 164 children completed the study (95.9% of initial participants; 89.5% of matched triads). Reasons for non-completion not reported
- *Age:* Not reported (fourth grade students)
- *Other relevant demographics:* See table below

Baseline Characteristics (mean±SD)

	High Sodium	Low+ Sodium	Low Sodium
Males (N=26)			
SBP (mmHg)	101.0±7.7	101.2±7.4	101.3±9.2
DBP (mmHg)	59.0±9.3	57.8±12.2	58.0±9.5
Weight (kg)*	34.3±5.9	36.3±6.5	34.0±6.5
Females (N=25)			
SBP (mmHg)	97.5±8.7	97.6±9.7	97.7±10.1
DBP (mmHg)	56.4±11.1	56.9±10.2	56.1±9.2
Weight (kg)*	32.5±5.1	33.6±6.0	29.8±4.2

*P<0.05.

- *Location:* Massachusetts.

Summary of Results:

- All three groups exhibited a drop in BP over the study period, characteristic of becoming more familiar with the screening situation
- Among the girls, a consistent pattern of a greater drop in BP among the Low group was evident for both systolic BP (SBP) and diastolic BP (DBP)
- However, there was no consistent difference among the groups in the pattern of drop in BP among the boys. An initial effect was not sustained beyond the first month
- The pattern of difference between boys and girls in SBP and DBP change was similar, with girls having a greater decrease than boys in both cases, the differences being statistically significantly different at P=0.033 for the difference in change in DBP
- Testing difference in change in SBP or DBP between the two high Na water groups (High vs. Low+) revealed no significant (NS) difference for either boys or girls, for either SBP or DBP
- None of the differences in urinary Na or K excretion were statistically significant over the study period among the groups, nor was there a significant correlation between Na excretion and BP
- Na excretion levels did not differ significantly between the sexes
- Average daily Na intake differed between the groups, but differences were not statistically significant
- Adjustment for dietary Na intake had little effect on the pattern of BP change among the three water groups for either male of females.

Average Daily Na Intake at Baseline and Overall by Water Groups for Males and Females		
Group	**Baseline**	**Overall**
Males		
High N=15	3,290	2,964
Low+ N=16	3,684	3,390
Low N=15	4,267	3,631

Females		
High N=15	2,737	2,512
Low+ N=14	3,515	2,944
Low N=15	3,170	3,132

Differences in Change in Blood Pressure (mmHg) from Baseline at Weeks Two to Four and 10 to 12 for Average Daily Dietary Na Intake, by Water Group for Males and Females

	Baseline to Weeks Two to Four		Baseline to Weeks 10 to 12	
Group	**Unadjusted**	**Unadjusted**	**Unadjusted**	**Adjusted**
Males				
Systolic				
High	-2.4	-2.8	-3.6	-3.5
Low+	-3.0	-4.0	-4.2	-4.3
Low	-2.4	-2.8	-0.5	-0.6
Dystolic				
High	-3.9	-4.6	-7.6	-7.3
Low+	-3.9	-9.3	-3.7	-3.7
Low	-7.2	-5.3	-2.4	-2.2
Females				
Systolic				
High	-3.6	-3.4	-3.3	-3.3
Low+	-4.5	-5.7	-6.0	-6.0
Low	-5.8	-6.1	-6.8	-6.8
Dystolic				
High	-1.2	-4.6	-3.0	-2.9
Low+	-2.6	-5.6	-6.8	-6.7
Low	-6.8	-12.2	-10.3	-10.5

Author Conclusion:

- The female data seemed to indicate a sensitivity of BP to reduction of small amounts of Na in the drinking water. However, the male data did not provide support for this effect
- Whether these differences in effect by sex may have been due to differential compliance among the boys, which was not apparent in the compliance questionnaires, or whether the differences have other explanations awaits further research.

Reviewer Comments:

- *No information about baseline risks for disease or concurrent illnesses were given. All that is given is that the participants were previously enrolled in another study the year prior*
- *The study design was randomized, but the method of randomization was not given*
- *Reasons for withdrawal from the study or non-completion was not given*
- *Statistical methods were not described in the methods section*
- *Physical activity and exercise could contribute to decrease BP but was not accounted for*
- *No control over school lunch preparation.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes

Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	???
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	???
2.2.	Were criteria applied equally to all study groups?	???
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	???

3.	**Were study groups comparable?**	No
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	No
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	No
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	N/A
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	No
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	No
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	No
4.4.	Were reasons for withdrawals similar across groups?	???
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	Yes
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	N/A
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A

5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	N/A
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	???
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	No
8.1.	Were statistical analyses adequately described and the results reported appropriately?	No
8.2.	Were correct statistical tests used and assumptions of test not violated?	???

8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	No
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	No
8.7.	If negative findings, was a power calculation reported to address type 2 error?	No
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**	No
9.1.	Is there a discussion of findings?	No
9.2.	Are biases and study limitations identified and discussed?	No
10.	**Is bias due to study's funding or sponsorship unlikely?**	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes